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ARROWIPORA FROMENSIS A NEW GENUS AND SPECIES OF TABULATE-LIKE CORAL FROM THE EARLY CAMBRIAN MOOROWIE FORMATION, FLINDERS RANGES, SOUTH AUSTRALIA

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Summary

FULLER, M. K., & JENKINS, R. J. F. (1995) *Arrowipora fromensis*, a new genus and species of tabulate-like coral from the Early Cambrian Moorowie Formation, Flinders Ranges, South Australia. *Trans. R. Soc. S. Aust.* **119**(2), 75-82, 31 May, 1995.

The recently discovered Early Cambrian tabulate-like coral *Arrowipora fromensis* gen. et sp. nov. occurs in the Moorowie Formation of the eastern Flinders Ranges. It is found in an ancient reefal environment in association with *Moorowipora chamberensis* Fuller & Jenkins 1994 and *Flindersipora bowmani* Lafuste 1991. *Arrowipora fromensis* has tabulate-like characteristics including the ceriod form of the corallum, wedge-shaped to spine-like septa and strongly developed dissepiment-like tabulae. Although unlike any other Early Cambrian coral, skeletal characteristics are similar to some michelinids, which have a time range from the Late Silurian to the Late Permian. *Arrowipora fromensis* provides further evidence that the time range of the Subclass Tabulata possibly extended to the Early Cambrian.

KEY WORDS: *Arrowipora fromensis*, Early Cambrian, Moorowie Formation, tabulate-like coral, Flinders Ranges, South Australia.

Introduction

Arrowipora fromensis gen. et sp. nov. occurs in the Early Cambrian Moorowie Formation in the eastern Flinders Ranges of South Australia in association with *Moorowipora chamberensis* Fuller & Jenkins 1994, and *Flindersipora bowmani* Lafuste 1991. It is present in slumped reefal blocks within a megabreccia at a site close to the disused Moorowie Mine (Fig. 1) described in Fuller & Jenkins (1994). The corals are preserved as upright coralla relative to bedding and clearly are in life position within individual slump blocks. They occur in association with both fragmental and encrusting remains of the calcimicrobes *Renalcis* Vologdin 1932, *Girvanella* Nicholson & Etheridge 1878 and *Epiphyton* Borneman 1886, and current-deposited archaeocyaths. The ancient reefal system may have been established on a marginal fan comprising a coarse breccia (Savarese *et al.* 1993). The high energy marine environment was responsible for the influxes of sediment preserved within the framework of the coral colonies. *Arrowipora fromensis* and the two previously described corals from Moorowie have few skeletal characteristics in common.

Preservation

The available material, collected many years ago by Mr Brent Bowman, then a technical assistant at the University of Adelaide, shows parts of probably one

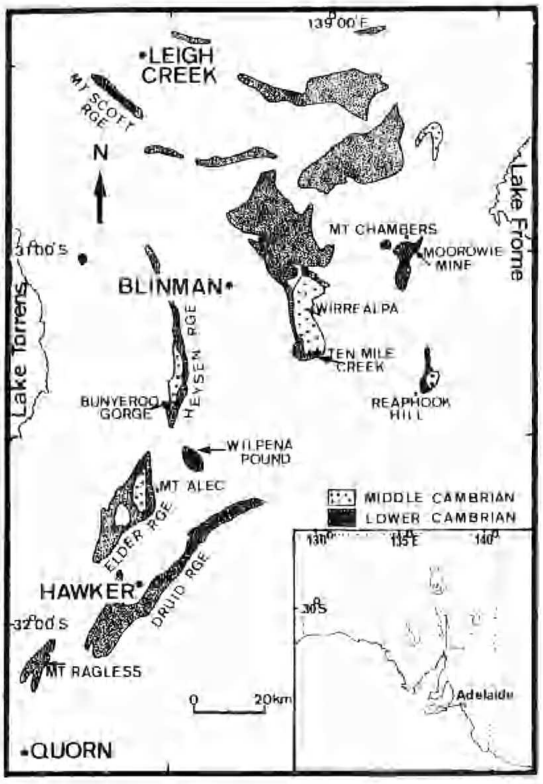

Fig. 1. Location map showing fossil occurrence near the Moorowie Mine and the distribution of Early and Middle Cambrian outcrops in the Flinders Ranges of South Australia.

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Fig. 2. Holotype SAM P34167 (complete specimen), illustrating rectangular shelves extending from a large colony (x1.0).

Fig. 3. Holotype SAM P34167 (reverse side of specimen shown in Fig. 2) with shelf-like projections across adjacent sediment (x1.0).

colony broken from a large specimen (Figs 2,3). During life the colony appears to have been repeatedly but partly covered by centimetre thick layers of fine sediment which now fill large spaces between lateral expansions of the corallum. Many corallites were smothered, allowing only a limited number to continue their growth. Subsequent corallites grew either inclined or spread laterally above the lenses of sediment. Transverse and oblique sections of small archaeocyaths lying on their sides relative to bedding are evident in cavities between extended shelves of the corallum (Figs 2,3). The geopetal infilling of the archaeocyaths further indicates that they were transported into the cavities with the sediment.

Calcareous sediments filling small cavities between the corallites have generally been recrystallized, while the calices (together with larger cavities) are usually filled with very fine sand or silt. Laterally extended shelves of the specimen SAM P34167 are irregularly rectangular or platy and project over the bioclastic and/or calcarenite matrix (Figs 2,3). Corallites also show indications of being eroded by rapid, energetic influxes of coarse sand. Calcite-filled fractures apparently related to post-diagenetic deformation of the corallum occur rarely (Figs 4B,C).

Recrystallization has affected all of the colony and some of the skeletal structures observed may be artifacts of diagenesis. There are, however, domains within the recrystallized fabric where some evidence of the primary structure of the skeleton appears to be preserved. These relic, rather robust fibrous elements which evidently formed the sclerenchyme (calcareous skeleton of corallites), are seen as either lineations across the walls of corallites (in transverse section) and/or divergent bundles (in longitudinal section) (Figs 4E,5D).

In longitudinal section, upturned spines along some corallite walls (Fig. 4C), and spines situated on the upper surface of some tabulae (Fig. 4D) are represented by bundled fibres, giving both the wall and tabulae a bumpy appearance. In transverse section, most septa appear to terminate in fan-shaped arrays of fibres, or similar arrays arise from the walls (Fig. 5C). The bundled fibres resemble primitive trabeculae. However, fan-shaped tufts in carbonates often result from diagenesis (Oekentorp 1989).

Systematic palaeontology

Phylum: CNIDARIA
Class: ANTHOZOA
Subclass: ?TABULATA
Family: uncertain

Genus: ***Arrowipora*** gen. nov.
Type species: *Arrowipora fromensis* sp. nov.

Etymology

For the Arrowie Basin, an Early Cambrian shallow marine basin, extending over much of the area of the present Flinders Ranges of South Australia.

Diagnosis

Corallum large, massive cerioid, comprising polygonal corallites; corallites prismatic and irregularly cylindrical; walls separated by a medial plane, thick, wavy to crenate, sometimes almost straight; tabulae numerous, rarely complete, commonly dissepiment-like tabellae; septa numerous or absent, numbering up to 35 in each corallite; where present septa form short wedge- to spine-like projections into the lumen; mural pores absent.

Arrowipora fromensis sp. nov.
FIGS 2-5

Etymology

For nearby Lake Frome.

Diagnosis

As for genus.

Type specimens: The specimens described in this paper are held at the South Australian Museum (SAM). Holotype SAM P34167, a polished slab of a broken part of a corallum and thin sections SAM P34167-1, SAM P34167-2. Paratype SAM P31962-1, SAM P31962-2, counterparts comprising two triangular, large, cut, polished slabs approximately 34 cm normal to bedding and 28 cm parallel to bedding, containing either two coralla or more likely the disjunct parts of one large corallum which formed numerous platy shelves. Thin section SAM P34168-1. The material was collected from the Moorowie Formation, near the Moorowie Mine in the eastern Flinders Ranges (Fig. 1).

Description

Colony large, more than 24 cm tall and extending laterally well in excess of 23 cm. In longitudinal section the corallum may broaden upward, or more commonly, forms wide shelves extending laterally over the adjacent sediment. Shelves are either irregularly rectangular in shape, with corallites tending to diverge slightly, or are plate-like. Individual shelves measure up to 70 mm high and 130 mm in width (Figs 2,3). The upper surface of the shelves is irregularly horizontal to concave, and calices may extend up to 7 mm above the uppermost tabellae. In transverse section (Figs 5A,B,C), the cerioid corallites, are seen as 5-8 (generally 6) sided polygons, varying between 10 and 14 mm in diameter.

Walls are relatively thick, varying between 0.1 mm and 1.0 mm, and are wavy to almost straight. The inner surfaces of the walls are irregular, due to the insertion

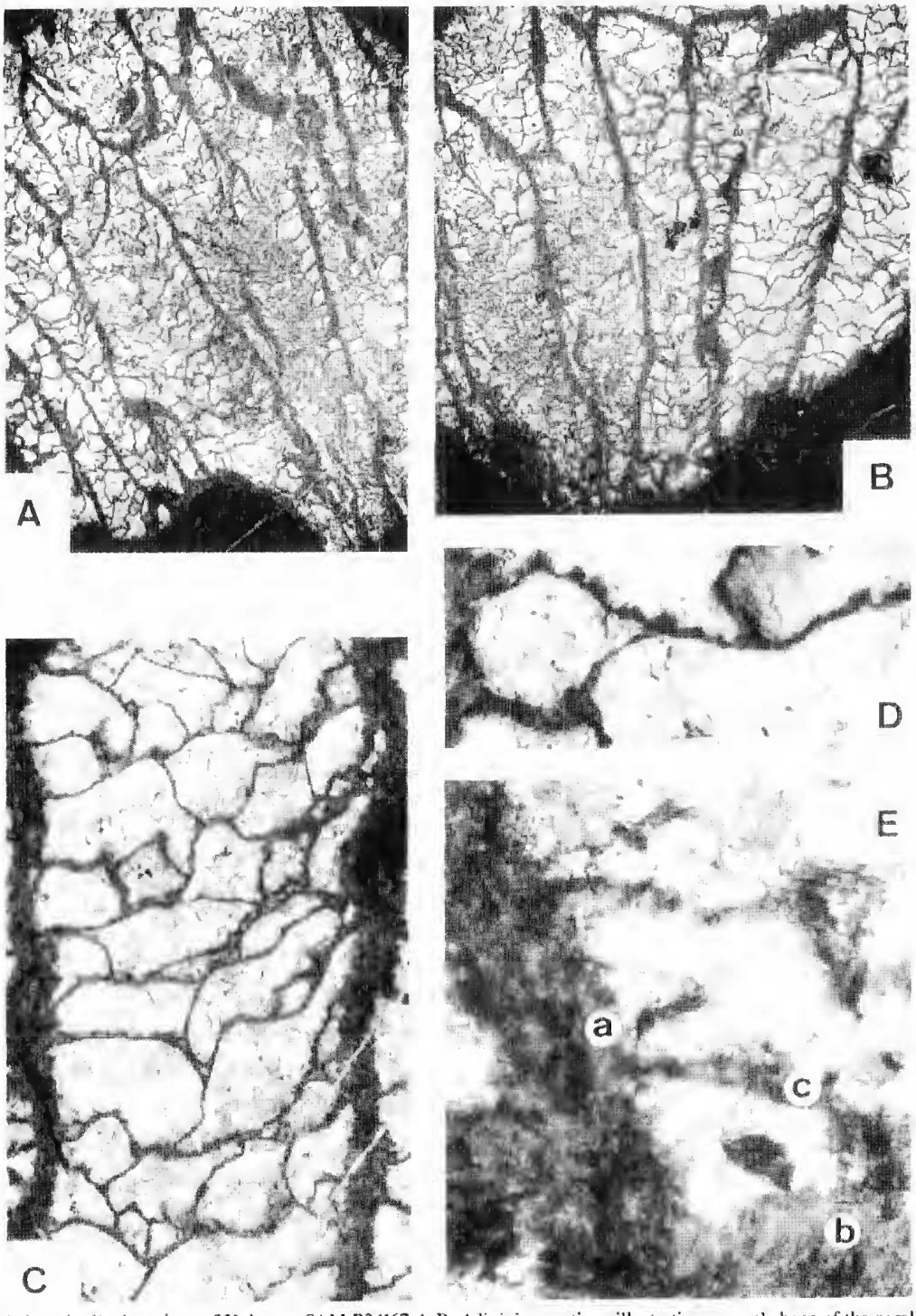

Fig. 4. Longitudinal sections of Holotype SAM P34167 A,B. Adjoining sections illustrating general shape of the corallites, tabulae, vertical and basal corallite walls (x2.4). C. The irregular surface of the walls and upper surface of tabulae. Two fractures which post date growth are observed mid-to lower-right of figure, together with the recrystallized fabric within the corallite (x10.6). D. Enlarged section (x2.4) of corallite (lower right Fig. 4B) illustrating tabulae with possible septal spinules on the upper surface. E. Higher magnification (x40) of a corallite section illustrating diverging fibres of a vertical wall, a; and the similar structure of the basal wall, b; and tabulae, c.

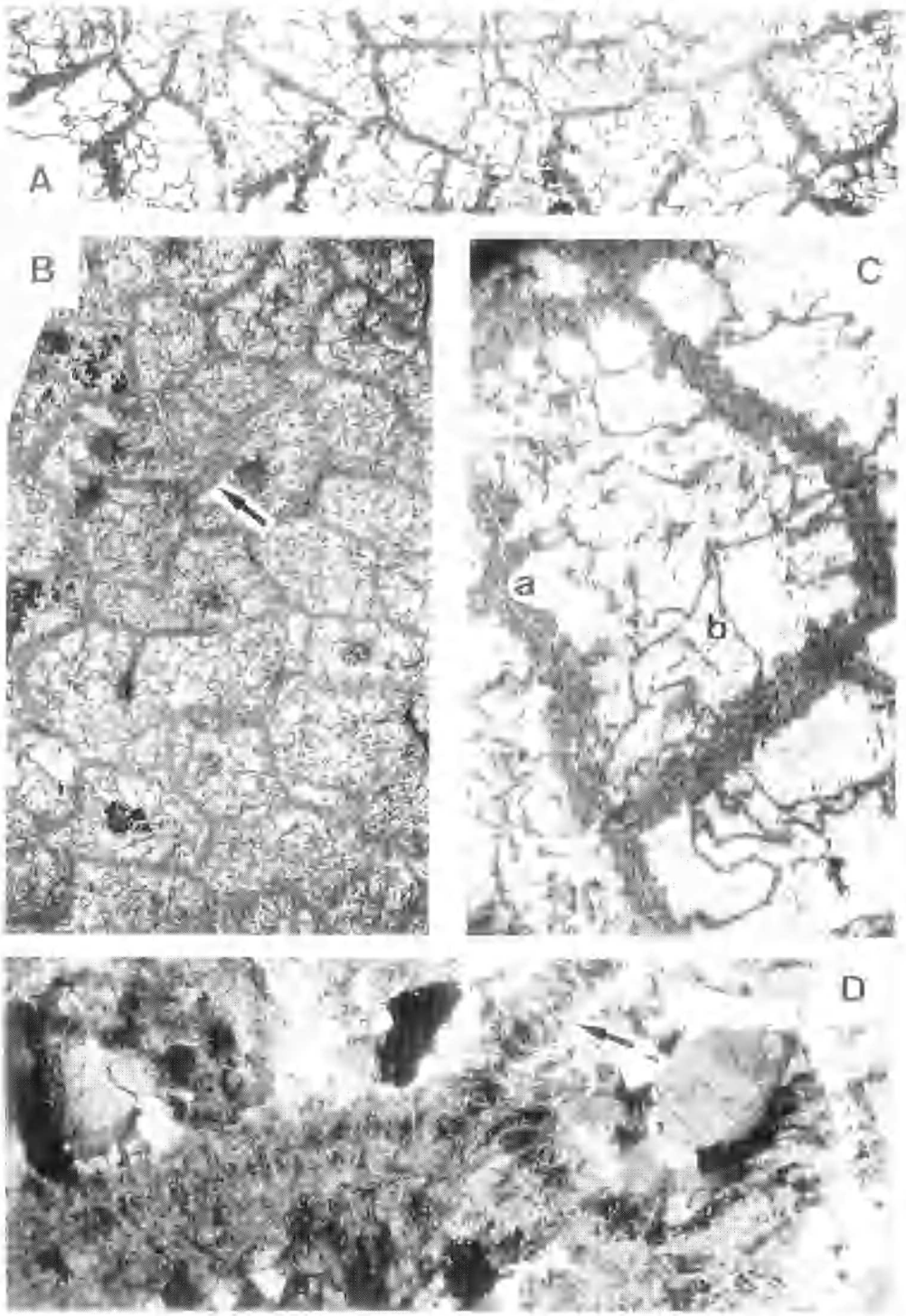

Fig. 5. A. Transverse section of Holotype SAM P34167 (x3.8). B. Transverse section of Paratype SAM P34168 (x4.5) showing variation in corallite shape and septa. Tabulae are observed as irregular lines crossing the corallite: the midline of the wall (arrowed) may be seen in some adjoining corallites. C. Enlarged section (x10.5) of 5A illustrating septa, wall irregularities, midline a and tabulae b. The recrystallized fabric is observed within the corallite. D. Corallite walls (x40) showing the bundles of fibres which cross the wall (arrowed) in sections of the specimen.

of numerous tabellae and septal spines. In thin sections, a medial line divides the walls of adjoining corallites (Figs 5A,C).

In transverse section at low magnifications (up to X 40) straight to slightly diverging fibres crossing the walls between adjacent corallites are commonly disrupted by the medial line (Figs 5A,B,C,D). In longitudinal section, fibrous elements diverge outward and upwards from the medial line and often protrude into the lumen giving the walls an irregular appearance. The walls which truncate parent corallites and form the base of subsequent corallites, are composed of vertical to slightly inclined fibres. These partitions arise from the vertical walls and are usually V-shaped, but may be undulating, horizontal or inclined (Figs 4C,D,E).

In longitudinal section (Figs 2,3,4A,B,C), individual corallites are prismatic to irregularly cylindrical and up to 14 mm wide and 47.5 mm long. Corallites vary little in diameter and length, prior to the addition of new corallites (increase). Increase is both lateral and peripheral intracalicular- parricidal within the established body of the colony (Figs 2,4A,B).

Tabulae are numerous, commonly formed of incomplete-, globose and dissepiment-like tabellae. Occasionally some are continuous across very narrow corallites. Tabellae may arise from the wall, or from adjacent tabellae, extending inward and curving downwards to rest upon other tabellae. They are very thin, generally less than 0.06 mm, often wavy and rarely straight. Small projections often occur on the upper surface of tabulae (Fig. 4D). In transverse section, tabellae are seen as wavy and crenate, arising from the walls and anastomosing with adjacent tabellae (Figs 5A-C). At low magnification, the fibrous structure of the tabellae is similar to that of the walls, with some bundles extending to give the small projections on the upper surface. In longitudinal section, the fibrous elements are normal to the base of the tabellae.

In transverse section, septal spines vary from numerous (about 35) to absent and are often difficult to distinguish from other irregularities on the wall (Figs 5A,B,C). Where present they are short (up to c. 0.25 mm), generally equal in length, blunt triangular or spine-like in shape and equidistant from each other (about 0.25 to 0.5 mm). They are commonly present on some walls while absent on others within a single corallite. Septal spines appear to be continuations of bundles of fibres of the fibrous wall, usually terminating as, or being seen as fan-shaped tufts (see above - **Preservation**). In longitudinal section, the generally upturned septal spines are observed to occasionally form short vertical rows on corallite walls.

Discussion

A. fromensis is unlike the two previously described Early Cambrian corals from the same location, *Flindersipora bowmani* Lafuste 1991 (e.g. Lafuste *et al.* 1991) and *Moorowipora chamberensis* Fuller & Jenkins 1994. *A. fromensis* is distinguished from *F. bowmani* by the size and general form of the colony, the position and shape of tabulae and septa, as well as the mode of increase. In *F. bowmani*, tabulae are mostly complete and concave proximally; there are 6-16 strongly developed slightly curved septa, the edges of which bear very short blunt spines; the walls are very short segments between the septa. Increase is by longitudinal fission.

The main differences between *A. fromensis* and *M. chamberensis* are in the size and form of the colonies, the size and shape of the corallites and the arrangement and shape of tabulae. Although both are cerioid in colonial form, the former is much larger and usually has parallel corallites, while those in *M. chamberensis* are generally divergent. Corallites are prismatic to cylindrical and up to 14 mm in diameter and 47.5 mm in length in *A. fromensis*, but much smaller (up to 5 mm in diameter and 19.5 mm in length) and tuboroid to irregularly cylindrical in *M. chamberensis*. The presence or absence of septal spines is common to both corals: when present they are about the same size and shape.

Tabulae differ greatly, being incomplete, globose and dissepiment-like (tabellae) in *A. fromensis* and complete, undulating and horizontal to concave upward in *M. chamberensis*. Although the microstructure has not been studied at high magnification, there are some similarities between the above corals at low magnification. These include the parallel fibrous elements of the sclerenchyme evident in transverse section, and the parallel to diverging fibrous elements in longitudinal section. Fan-like arrays of fibres are not present in *M. chamberensis*. A medial line within walls of adjacent corallite occurs in both corals. Medial lines in the walls are common in tabulate corals, and represent the external epitheca (Hill 1981).

A. fromensis is unlike any of the previously described Cambrian corals suggested by Scrutton (1979) to have tabulate affinities, but does have skeletal characteristics in common with some of the Late Silurian to Late Permian michelinids.

The diagnostic characteristics for the genus *Michelinia* De Koninck 1841 include thin to moderately thick walls with a medial suture, short septal trabeculae, tabulae incomplete and globose sometimes with septal spinules on the upper surface, and large mural pores (Hill 1981). The walls and tabulae are similar to those seen in *A. fromensis* but the present taxon lacks mural pores.

Michelinia expansa White 1883 [*Tabellaephyllum peculiare* Stumm 1948] (Stumm 1948) from the Early Carboniferous of Arizona, is similar to *A. fromensis* with respect to the form of the colony, the size and shape of corallites and the arrangement of labellae. Corallites are up to 15 mm in diameter in the former and 14 mm in the latter. Corallites are also of a similar shape, being generally 4, 5 or 6 sided, but differ by the lack of septa in *M. expansa*. A most noticeable similarity between the two is the placement, size and shape of the tabellae. They are incomplete and globose and are arranged in similar manner in both taxa, arising from either the walls or adjacent tabellae. The tabellae in *A. fromensis* appear to be less globose, spaced slightly further apart, and have a more irregular and wavy surface.

Although *A. fromensis* most closely resembles some of the micheliniids, because of the long time separation between them (~120 million years) it is highly unlikely that they are related and more probable their skeletal similarities result from convergent evolution.

Conclusions

The three described corals from the Moorowie Formation, *A. fromensis*, *M. chamberensis* and *F. bowmanii*, are very different in form and arrangement of the skeleton. The diverse nature of the corals from this ancient reefal environment indicates that during the Early Cambrian, variability in polyp form and skeletal morphology was well established.

The genus *Lichenaria* has been recognized as the earliest tabulate coral, with a time range from the base of the Early Ordovician to the early Late Ordovician (Scrutton 1979, 1984, 1992; Hill 1981). It has been described as primitive, cerioid, of simple morphology, aseptate, but with tabulae and rare mural pores (Bassler 1950; Flower 1961; McLeod 1979; Scrutton 1984; Laub 1984). Although *A. fromensis* lacks mural pores, it has a similar skeletal structure to some micheliniids which post-date *Lichenaria*. Most of the skeletal aspects of *A. fromensis* are characteristic of Palaeozoic tabulate corals. These are (1) the cerioid form of the colony; (2) walls separated by a medial line reflecting individual corallites (Scrutton 1987); (3) the spine-like to wedge-shaped septa occasionally situated in longitudinal rows (Hill 1981); (4) individual corallites which spread above the pockets of sediment within the colony, this habit being usual for cnidarians following influxes of sediment (Scrutton 1979); (5) lateral increase common, with peripheral intracalicular increase being described in some Favositidae (Hill 1981). Although tabulae are incomplete and dissepiment-like, they are consistently and strongly developed both within individual and between adjacent corallites in *A. fromensis*.

A. fromensis has anthozoan structural characteristics, most of which are evident in tabulate corals. It should therefore probably be included in the known group of tabulates, thus extending the time range of this group to the late Early Cambrian.

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